Bay Area
Freeway Concept of Operations

Communications Master Plan
and
Implementation Plan

Deliverable No. 29

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1. EXECUTIVE SUMMARY

The California Highway Patrol (CHP), Metropolitan Transportation Commission (MTC) and the California Department of Transportation (Caltrans) District 4 have undertaken a Freeway Concept of Operations Study for the San Francisco Bay region. The purpose of the study is to identify strategies to effectively manage recurring traffic congestion, incident response, traveler information and corridor management on freeways in the Bay Area.

The goal of the Bay Area Freeway Concept of Operations project is to improve freeway operations policies, procedures, and practices, and build consensus on the roles, responsibilities, and resource needs for freeway operations. Freeway operations are the activities that directly affect the safety, travel time, travel route selection, time of travel, or mode of travel, of travelers using or planning to use the freeway network. Phase 1 of the Concept of Operations project will result in a Freeway Operations Strategic Plan Report that recommends the future direction for freeway operations in the Bay Area, and an Action Plan that will guide future work on the Freeway Concept of Operations. The Strategic Plan identifies 15 strategies for improving freeway operations, one of which is to establish a sustainable communications system. The Communications Master Plan is the first step in developing that strategy.

1.1 Scope

This is the draft version of the seventh of seven deliverables related to the development of a communications master plan for the Bay Area freeway operations systems. The Communications Master Plan and Implementation Plan are combined in this deliverable to fully describe the master plan and how it is to be implemented. The seven deliverables are:

1. Communications Inventory;
2. Evaluation Criteria and Communications Alternatives;
3. Communications Alternatives;
4. Draft Communications Master Plan;
5. Final Communications Master Plan;
6. Draft Implementation Plan; and
7. Final Communications Master Plan and Implementation Plan.

There are several agencies in the Bay Area needing communications systems to support their mission. To date, each agency has planned, designed, and deployed its individual system. The California Department of Transportation (Caltrans), Metropolitan Transportation Commission (MTC), and the California Highway Patrol (CHP) recognize an opportunity for agencies to share infrastructure to more efficiently accommodate the different communications requirements.

The purpose of the Communications Master Plan and Implementation Plan is to coordinate investments in communications infrastructure by the various agencies involved in Freeway Operations, which include the three regional agencies (Caltrans, MTC, and CHP) as well as local transportation, police, fire, and emergency medical agencies. The project defines an approach to improve communications between a) the Regional Traffic Management Center (TMC) located in Caltrans and stationary field equipment owned by Caltrans or MTC, and b) the Regional TMC and TMCs developed by Smart Corridor projects throughout the Bay Area.

Because of the shear size, complexity, and cost of implementing a regional communication system, the project will be developed and deployed in stages. A Communications Master Plan and Implementation Plan is necessary to serve as a guide to help effectively plan, design, and build a communication system capable of meeting the communications needs for the Bay Area's Freeway Operations Systems. The Communications Master Plan and Implementation Plan presents a logical plan to follow as individual segments of the total system are placed in operation. Each design and construction phase will then logically build on each preceding phase of the selected communication alternative.

1.2 Summary of Communications Master Plan and Implementation Plan Concepts

The Communication Master Plan and Implementation Plan details a logical progression for the Bay Area Freeway Operations to buildout the communications system such that bandwidth increases, and recurring costs decrease by optimizing existing infrastructure to the extent possible, and adding communication links where practical. The proposed communications backbone will utilize two of Caltrans' four existing optical fibers in the Bay Area Rapid Transit (BART) system and extend the optical path to connect the Regional TMC to the smart corridor TMC's and Caltrans field communication hubs. The main points presented in this report to achieve the stated goals are:

- The communications backbone is divided into four separate phases for implementation. Three of the phases have been further divided into smaller segments. The four phases consist of the following:
  - In Phase 1, existing fiber installed by BART or other agencies will be used to interconnect the smart corridor TMCs and selected Caltrans hubs to the Regional TMC, reducing the requirement for expensive high-bandwidth leased communication links. Where fiber does not exist, fiber will be added to complete the links. The smart corridor TMCs and hubs interconnected in this phase are:
    - Silicon Valley-ITS at the San Jose TMC;
    - Tri-Valley Smart Corridor at the Pleasanton TMC;
    - I-680 hub at Walnut Creek (existing);
    - Caltrans Benicia Bridge hub;
    - San Francisco TMC (SFgo); and
    - Vallejo CHP.

    Installing fiber along I-680 and I-780 enables the transfer of approximately 26 closed-circuit television (CCTV) cameras, 5 changeable message signs (CMS), 21 detector stations, and 2 highway advisory radio (HAR) from leased communications to the Caltrans fiber system.

    The projected total implementation cost for Phase 1, including $500,000 for center to center software, equipment, and systems integration, is $3,079,000, plus $20,440 annual maintenance cost.
  - In Phase 2, existing fiber along I-680 will be utilized to interconnect the Caltrans hub near the Walnut Creek BART Station to the East Dublin/Pleasanton BART station access point. This phase will form the beginnings of a ring topology offering fiber path redundancy.

    Fully activating the fiber along I-680 enables approximately 26 CCTV cameras, 1 CMS, 58 detector stations, and 4 ramp meters to function over the Caltrans fiber optic system.

The projected total implementation cost for Phase 2 is $746,000, plus $13,500 annual maintenance cost.

- In Phase 3, other Caltrans hubs will be connected to the backbone. The Caltrans hubs that will gain connectivity to the Regional TMC via this phase are:

  - Caltrans San Mateo Bridge hub;
  - Caltrans Dumbarton Bridge hub;
  - Caltrans San Jose, Knox Avenue hub; and
  - Caltrans Bay Bridge hub.

  Installing fiber along I-880 and connecting the Caltrans hubs enables the transfer of approximately 118 CCTV cameras, 20 CMS, 71 detector stations, 3 HAR, and 38 ramp meters from leased communications to the Caltrans fiber system.

  The projected total implementation cost for Phase 3 is $4,310,000, plus $25,030 annual maintenance cost.

- In Phase 4, approximately 54.4 miles of fiber will be installed along US 101. This Phase will offer path redundancy for the following smart corridor TMCs and Caltrans hubs.

  - Silicon Valley-ITS at the San Jose TMC;
  - Caltrans San Jose, Knox Avenue hub;
  - Caltrans Dumbarton Bridge hub;
  - Caltrans San Mateo Bridge hub; and
  - San Francisco TMC (SFgo).

  Installing fiber along US 101 enables the transfer of approximately 67 CCTV cameras, 16 CMS, 147 detector stations, 7 HAR, and 24 ramp meters from leased communications to the Caltrans fiber system.

  The projected total implementation cost for Phase 4 is $15,409,000, plus $36,400 annual maintenance cost. Phase 4 is presented in two phases due to the size of this phase. The projected implementation cost for Phase 4A is $8,970,000 and for Phase 4B is $6,439,000 with annual maintenance costs projected as $21,720 and $14,680 respectively.

- Total implementation cost is $23,544,000.
- After initial connectivity is implemented for the smart corridor TMCs, fiber path redundancy is added to help ensure failure free operation in spite of fiber cuts. Caltrans communication hubs are then added to the backbone communications, reducing the requirement for expensive high bandwidth leased communication links.
- Selected freeways will have new conduit and fiber installed. This serves the purpose of greater path redundancy and fault tolerance, as well as moving several traffic operations system (TOS) field elements off leased services and onto the fiber to communicate with the nearest hub. In total, approximately 232 existing CCTV cameras, 42 existing CMS, 302 existing detector stations, and 66 ramp meters will move from leased services to agency-owned fiber installed along the freeways.
- The Backbone fiber infrastructure in this plan will support either of the two most widely used wide area network (WAN) technologies available today (SONET or Gigabit Ethernet).
- Because of the size, complexity, and cost of implementing a regional communication system, the project will be developed and deployed in stages. The Implementation Plan in Section 7 describes a phased plan for building the communications backbone for the Bay Area freeway

operations. A schedule for implementation and opinions of cost are presented. The Implementation Plan addresses the need to provide communications to existing equipment and systems, as well as with new equipment and systems as they come on-line. The Implementation Plan is consistent with the schedule for the TravInfo® deployment of a data collection system, the Caltrans TOS/TMC upgrades and the local Smart Corridor implementations.

- The Implementation Plan presents four Phases for incremental buildout of the communications backbone. The initial steps will entail development of a Memorandum of Understanding for the regional agencies and smart corridors that addresses responsibilities for the design, construction, ownership, operations, and maintenance of the communications backbone system.
  - Phase 1 connects the Regional TMC in Oakland to the CHP Division Headquarters in Vallejo and the smart corridor TMCs using the BART fibers allocated to Caltrans and fiber optic cable being installed in the Smart Corridor programs. Phase 1 is shown as funded in Fiscal Year 2003/2004, operational in calendar years 2004 and 2005 at a cost of $3,079,000, which includes $500,000 for center to center software, equipment, and systems integration.
  - Phase 2 completes a communications ring for redundancy by activating the existing fiber optic cable along I-680 from Dublin to Walnut Creek. The TOS field elements along I-680 are to be connected to the fiber optic cable thus eliminating the need to lease telephone service to communicate with these devices. Phase 2 is shown to be operational in 2004 at a cost of $746,000.
  - Phase 3 connects the Caltrans hubs to the communications backbone, permitting both the TOS and security cameras on the bridges to be linked to the Regional TMC by way of the fiber optic communications backbone. Phase 3 is shown to be operational in 2007 at a cost of $4,310,000.
  - Phase 4A is the first of two phases on US 101 from the interchange with SR 92 to the Caltrans hub in San Jose. This implementation will create a communication ring for redundancy and will permit the TOS elements along this portion of US 101 to be connected to the Regional TMC by fiber optic cable eliminating the leasing costs. Phase 4A is shown to be operational in 2009 at a cost of $8,970,000.
  - Phase 4B is the second of two phases to build a fiber optic communications path along US 101 from San Francisco to San Jose. Phase 4B includes the portion of this route from San Francisco to the interchange with SR 92. This implementation will create a communication ring for redundancy and will permit the TOS elements along US 101 to be connected to the Regional TMC by fiber optic cable eliminating the leasing costs. Phase 4B is also shown to be operational in 2009 at a cost of $6,439,000.
- The total cost for these phases is $23,544,000.

2. MASTER PLAN

2.1 Introduction

The Communications Master Plan and Implementation Plan report is organized into the following sections:

- **Section 3 – Existing Conditions,** depicts the existing and planned agency-owned communications infrastructure. Included in this section is a map of the communications infrastructure showing fiber optic cabling and hub locations.
- **Section 4 – Backbone Topology/Technology,** briefly describes the different communication backbone alternatives.
- **Section 5 – Deployment Plan**, identifies logical segments of the communications system to be deployed. Included is an opinion of probable costs for construction, annual maintenance, and annual leases. These costs are presented in increments for the segments to be deployed.
- **Section 6 – Cost Breakdown by Phase,** contains a table of the Engineer's opinion of probable costs for the implementation of each phase.
- **Section 7 – Implementation Plan,** describes the primary activities associated with implementing each phase of the Communications Master Plan.
- **Section 8 – Implementation Schedule**, describes a schedule for spreading the design and construction activities over multiple years.
- **Section 9 – Funding**, describes the funding required for each year from 2002 through 2009 and possible sources of federal and state funding.

2.2 Acronyms

The following is a list of acronyms used in this report:

BART	Bay Area Rapid Transit
Caltrans	California Department of Transportation
CCTV	Closed-Circuit Television
CDPD	Cellular Digital Packet Data
CHP	California Highway Patrol
CMS	Changeable Message Sign
DSL	Digital Subscriber Line
EMS	Extinguishable Message Sign
FDN	Field Distribution Network
GIS	Geographic Information System
HAR	Highway Advisory Radio
ITS	Intelligent Transportation System
MTC	Metropolitan Transportation Commission
OC-48	Optical Carrier, Level 48 (2.488 Gbps)
SONET	Synchronous Optical Network
T1	Telecommunication transmission at 1.544 Mbps (DS-1 level signal)

Telco	Telephone Company (Service Provider)
TIC	Traveler Information Center
TMC	Traffic Management Center
TOS	Traffic Operations System
WAN	Wide Area Network

3. EXISTING CONDITIONS

The following section describes the existing, programmed, and planned field devices for the region, as well as the TMCs and hubs that require connectivity. Also discussed is accomodating freeway operations in the existing SONET OC-48 backbone currently linking the Caltrans District 4 TMC with the hub at the Walnut Creek BART station.

3.1 ITS Field Devices

The existing communications infrastructure for the Bay Area was detailed in Deliverable No. 23, *Communications Inventory*, and should be referenced for specific detailed information. The inventory was built upon a geographic information system (GIS) based Thomas Brothers base map provided by the MTC and used to locate the TOS elements, TravInfo® field elements, and agency-owned communications systems. The layers of the inventory map contain the following information:

- CCTV cameras, existing and proposed;
- CMS, existing and proposed;
- HAR devices, existing and proposed;
- Monitoring station detection points, existing and proposed;
- Ramp meters, existing and proposed;
- Road weather information system (RWIS);
- Call boxes;
- Silicon Valley-ITS TMCs;
- Tri-Valley Smart Corridor TMCs;
- Regional TMC and Caltrans field hubs;
- San Francisco TMC (SFgo), proposed;
- TravInfo® Traveler Information Center (TIC); and
- CHP Golden Gate Division Headquarters.

Table 1 summarizes the existing, programmed, and planned field elements anticipated for support of the Bay Area freeway operations.

Table 1 – Summary of Freeway Operations Communications Infrastructure Field Elements

Field Element Description	Existing			Programmed Quantity	Planned Quantity	Total Quantity
	Quantity	Comm Type	Bandwidth			
Caltrans TOS						
CCTV	502	Various[1]	Various[1]	142	156	800
CMS	123	Dial-up	19.2 kbps	23	24	170
HAR	39	Dial-up	56 kbps	10	6	55
Ramp Meters	283	CDPD	9.6 kbps	96	661	1040
Detector Stations[4]	819	CDPD	19.2 kbps	148	533	1500
RWIS	1	Dial-up	56 kbps	0	0	1
Security CCTV	0	CDPD	19.2 kbps	250	0	250
EMS	82			47	171	300
Call Boxes						
Call Box Locations	3495	Combination[2]	56 kbps	0	0	3495
TravInfo®						
Toll Tag Readers	0	CDPD[3]	—	250	0	250

Note 1: Approximately 49% of the TOS CCTVs send video to a telco hub via telco leased lines at 56 kbps and 50% via telco leased ISDN lines at 128 kbps. There also are a few CCTVs that send analog video over fiber to a telco hub. At the telco hub all video is multiplexed onto T1 lines for transmission back to the TMC. Four CCTVs use wireless Ethernet 10baseT (10 Mbps) directly to the TMC.

Note 2: Both cellular and landline telephones are used.

Note 3: Programmed communications.

Note 4: Each station represents one cabinet, which in about 90% of the cases serves both directions of travel. There could be approximately 16 loops at one station (4 lanes in each direction times 2 loops per lane times 2 directions). Detectors for ramp metering are in addition to this number.

3.2 TMC/Hub Communication Infrastructure

Table 2 summarizes the TMCs, hubs, and the communication infrastructure in place supplying the connectivity.

Table 2 – Summary of Freeway Operations Communications Infrastructure – TMCs and Hubs

Description		Type Communications	Status
From	**To**		
Caltrans Field Hubs			
Walnut Creek, 1910 Olympic	Regional TMC	Fiber	Existing
San Jose, Knox Ave	Regional TMC	Leased Line	Existing
San Mateo Bridge toll plaza	Regional TMC	Leased Line	Existing
Dumbarton Bridge toll plaza	Regional TMC	Leased Line	Existing
Bay Bridge toll plaza	Regional TMC	Leased Line	Existing
Benicia Bridge toll plaza (future)	Regional TMC	Leased Line	Existing
San Rafael Bridge toll plaza	Regional TMC	Leased Line	Existing
Smart Corridor TMCs			
Silicon Valley – ITS			
Silicon Valley ITS TMC (San Jose)	Regional TMC[2]	Fiber	Programmed[2]
Cupertino TMC	Silicon Valley-ITS at the San Jose TMC	Fiber	Programmed
Fremont TMC	Milpitas TMC, Santa Clara TMC	Fiber	Programmed
Fremont TMC	BART fiber optic cable	Fiber	Programmed
Milpitas TMC	Fremont TMC, Santa Clara TMC	Fiber	Programmed
Los Gatos TMC	Silicon Valley-ITS at the San Jose TMC	Fiber	Existing
Santa Clara County TMC	Silicon Valley-ITS at the San Jose TMC	Fiber	Existing
Santa Clara TMC	Silicon Valley-ITS at the San Jose TMC	Fiber	Existing
Campbell TMC	Silicon Valley-ITS at the San Jose TMC	Fiber	Existing
East Bay Smart Corridor			
Alameda County TMC	Managed Server	Leased Line DSL	Existing
Alameda County Transit TMC	Managed Server	Leased Line DSL	Existing
Berkeley TMC	Managed Server	Leased Line DSL	Existing
Regional TMC	Managed Server	Leased Line DSL	Existing
CMA TMC	Managed Server	Leased Line DSL	Existing
Contra Costa County TMC	Managed Server	Leased Line DSL	Existing
Emeryville TMC	Managed Server	Leased Line DSL	Existing
Hayward TMC	Managed Server	Leased Line DSL	Existing
MTC TMC	Managed Server	Leased Line DSL	Existing
Oakland TMC	Managed Server	Leased Line DSL	Existing

Table 2 – Summary of Freeway Operations Communications Infrastructure – TMCs and Hubs

Description		Type Communications	Status
From	**To**		
Richmond TMC	Managed Server	Leased Line DSL	Existing
San Leandro TMC	Managed Server	Leased Line DSL	Existing
San Pablo TMC	Managed Server	Leased Line DSL	Existing
Tri-Valley Smart Corridor			
Tri-Valley TMC (Pleasanton)	Regional TMC	Leased	Programmed
Tri-Valley Smart Corridor at the Pleasanton TMC	Dublin TMC, Livermore TMC	Fiber	Programmed
Dublin TMC	Tri-Valley Smart Corridor at the Pleasanton TMC	Fiber	Programmed
Livermore TMC	Tri-Valley Smart Corridor at the Pleasanton TMC	Fiber	Programmed
San Francisco TMC (SFgo) (future)	Regional TMC	Fiber	Planned
TravInfo® TIC	Regional TMC	Direct Connect	Existing
CHP Golden Gate Division HQ	Regional TMC	Leased T1	Existing
BART Stations	BART Stations	Fiber[1]	Existing

Note 1: Caltrans will use four fibers in the BART fiber optic communications system.

Note 2: Fiber exists from Silicon Valley-ITS at the San Jose TMC to Milpitas TMC and from Milpitas TMC to Fremont TMC. Fiber is designed from Fremont TMC to BART fiber optic cable. BART fiber optic cable will be used to connect to Regional TMC.

3.3 Caltrans SONET OC-48

There are the beginnings of a Caltrans owned SONET communication backbone currently linking the Regional TMC with the Caltrans hub located near the Walnut Creek BART station. This SONET operates at the OC-48 level (2.488 Gbps) and currently has just the two hubs linked together in a folded (collapsed) ring topology. The addition of the fiber optic infrastructure discussed in this document will permit Caltrans to expand this high-speed digital backbone into a true ring throughout the Bay Area.

3.4 Cable Routing and Communications Hub Locations

Figure A is a map graphically depicting the existing communications infrastructure including the Regional TMC, Smart Corridors, Caltrans communication hub locations, and existing fiber optic cable and conduit routing.

Communications Master Plan
Existing Communications Infrastructure
Figure A

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June 2002

4. TOPOLOGY/TECHNOLOGY

4.1 Backbone Communication

As discussed in Deliverable No. 25, *Communications Alternatives*, there were four WAN alternatives considered for the Bay Area. Within these alternatives are differing technologies to consider as well; these will be discussed in greater detail later in this section. The alternatives are a fully agency-owned fiber optic backbone, agency-owned microwave backbone, fully leased backbone, and a combination of agency-owned fiber optic and leased backbone (hybrid). The microwave alternative was considered unacceptable because of line of sight restrictions, distance limitations, and potential interference, and concerns about its ability to function in the event of an earthquake. The fully leased option, while initially relatively inexpensive and easy to implement, quickly gets prohibitively expensive as the recurring costs continue to accrue ad infinitum. Because a great deal of the fiber required for backbone communications is existing via the BART infrastructure, it is determined that a fully agency-owned fiber optic backbone is the most cost effective and appropriate solution to link the Regional TMC to the smart corridor TMC's and Caltrans communication hubs. The existing fiber will be used to establish initial backbone communications, and then additional fiber will be installed to accommodate path redundancy in order to establish a fault tolerant network. This alternative was confirmed by the Technical Advisory Committee and Executive Committee as the basis for the Communications Master Plan and Implementation Plan.

4.2 Field Distribution Network

The communications system required for the complete Bay Area TOS extends far beyond backbone (high-bandwidth) communications between TMCs and Caltrans hubs. The Field Distribution Network (FDN), which links the lower bandwidth intensive field devices (i.e., CCTV, CMS, detectors) to the hubs, also needs to be considered. Because the Bay Area TOS is so vast, the capital costs to implement a fully agency-owned FDN is prohibitively expensive. Therefore, a hybrid (leased and agency-owned) FDN is planned. Initially, the FDN will primarily consist of leased services. As backbone fiber is installed along the freeway, those field devices adjacent to newly installed fiber can be removed from the leased services and added to the fiber network at a reasonable cost, thereby reducing the recurring costs for the system.

4.3 Technology

The high-stakes debate between SONET and Gigabit Ethernet is heating up in the telecommunications world, and for good reason. A description of both technologies along with advantages and disadvantages of each are discussed in the *Communications Alternatives* report. For the purposes of this communication master plan, a two-fiber backbone ring is being utilized with the expectation of connecting to the existing SONET OC-48 that currently interconnects the Regional TMC with the Walnut Creek BART station.

From a practical standpoint, for the purposes of this master plan, the end equipment that is ultimately used to interconnect the TMCs is not critical. The fiber path that is being proposed in this Communications Master Plan and Implementation Plan can be configured for and used with either technology.

5. DEPLOYMENT PLAN

The core of the Communications Master Plan and Implementation Plan revolves around creating a communications backbone utilizing existing single-mode fiber optic cables installed along BART rail lines. Where it is appropriate and feasible, additional fiber optic communications links are recommended to fill in gaps and/or to add a level of path redundancy to lower the expected maintenance requirements.

Caltrans has been authorized to use four fiber optic strands within the BART cables. The following locations have been designated as access points to the BART fiber for the purposes of this Master Plan and Implementation Plan. The access points are in the vicinity of these stations, not in the station itself. A branch cable has already been installed from the train control rooms at the stations to a cabinet or pull box in the Caltrans right-of-way. The one exception is the Civic Center Station where a new access point is proposed.

- Fremont Station;
- East Dublin/Pleasanton Station;
- Walnut Creek Station;
- Civic Center Station;
- Bay Fair Station; and
- Oakland 19th Street Station.

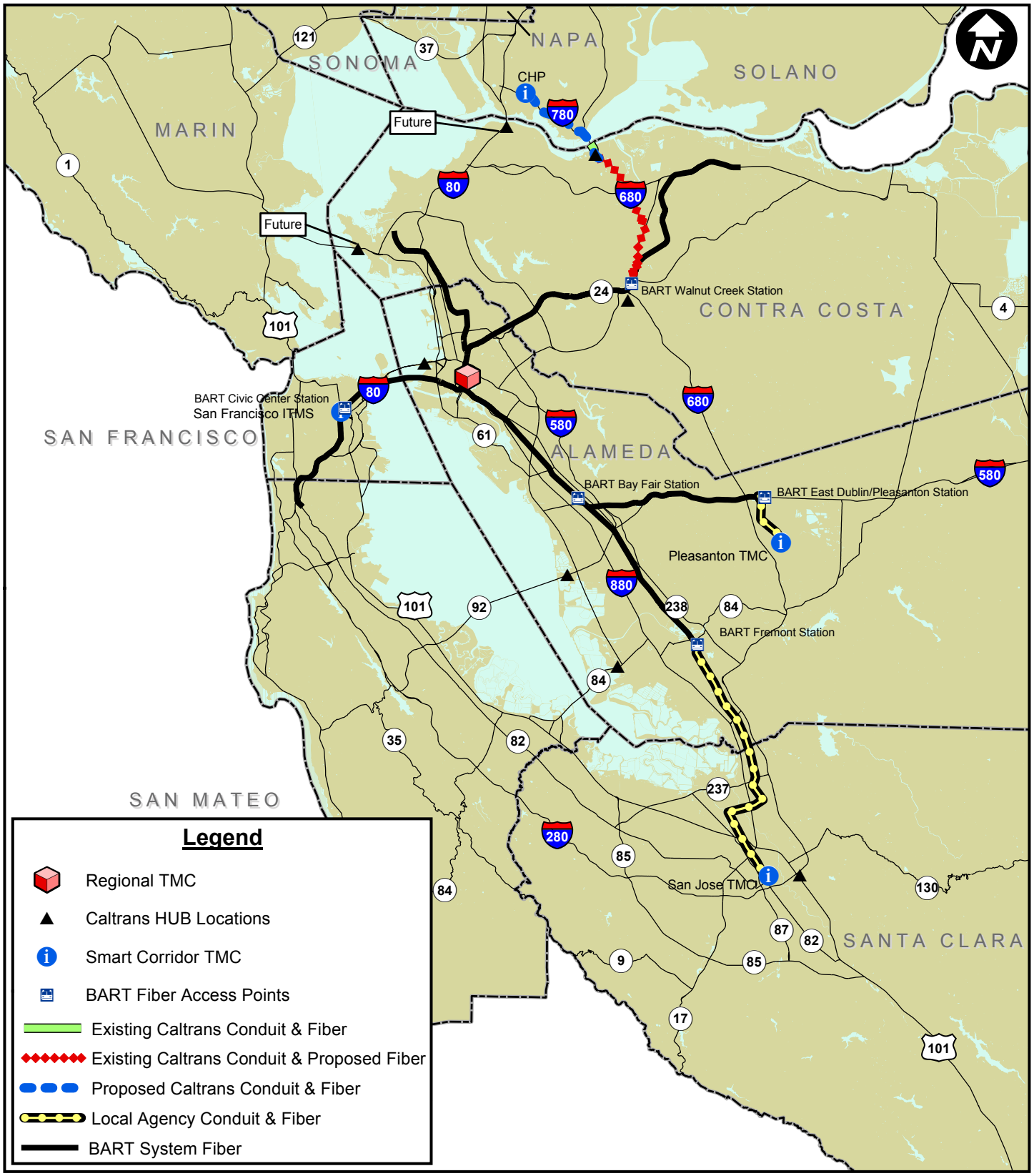
The utilization of the BART fiber to create a communication backbone occurs in the first phase, and is expanded in the subsequent phases. Three of the phases have been further partitioned into segments within the phase. The phasing is designed to get fiber connectivity from the Regional TMC to the smart corridor TMC's and Caltrans hub locations in the most effective way possible. As the fiber optic infrastructure is built out, the need for expensive, bandwidth limited, leased infrastructure will be reduced. The operating costs will decrease at the same time the bandwidth availability will increase dramatically.

The phases are broken down into a logical order. Once the backbone is complete, the remaining leased communications for the field distribution network can be converted to fiber as time and budget permit. The core of the backbone consists of the BART fibers. Each phase will add a segment to the BART fibers thereby creating the communications backbone.

5.1 Phase 1

The primary objective of Phase 1 is to get the Regional TMC in Oakland, CHP Division Headquarters in Vallejo, and smart corridor TMCs, plus two adjacent Caltrans communication hubs connected to the fiber backbone via the BART fiber interconnects. This will enable center-to-center connectivity, and a reduction in the use of expensive leased lines at the earliest possible time. The Smart Corridors interconnected via this phase are the Silicon Valley-ITS Smart Corridors at the San Jose TMC, the Tri-Valley Smart Corridor at the Pleasanton TMC, and San Francisco TMC (SFgo); and the Caltrans hub connected via this phase is the Caltrans Benicia Bridge hub. The Caltrans Walnut Creek hub is already connected to the Regional TMC.

The segments identified for Phase 1 are shown in **Figure 1**. In addition to the BART fibers, the total distance covered in Phase 1 is approximately 39.2 miles through five separate counties (Alameda, Santa Clara, Contra Costa, Solano and San Francisco). Of the 39.2 miles, 10 miles entail adding fiber in existing conduit, 5.7 miles are construction of new conduit and fiber, and 23.5 miles entail use of existing conduit and fiber installed by Smart Corridors and Caltrans.



Communications Master Plan
Phase 1
Figure 1

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5.1.1 Segment A

Segment A connects the BART fiber from the Fremont Station access point to the Silicon Valley-ITS at the San Jose TMC using local agency conduit and fiber (Fremont to San Jose Smart Corridor, this project is programmed and designed). The approximate distance for Segment A is 19.3 miles.

The estimated cost for Segment A is $131,000, which includes engineering costs and contingency. The cost is based on minimal fiber infrastructure construction costs, and hub communication equipment required at the Silicon Valley-ITS at the San Jose TMC.

5.1.2 Segment B

Segment B connects the BART fiber from East Dublin/Pleasanton Station access point to the Tri-Valley Smart Corridor at the Pleasanton TMC using local agency conduit and fiber (Dublin to Pleasanton Smart Corridor, this project is programmed and designed). The approximate distance for Segment B is 3.8 miles.

The estimated cost for Segment B is $117,000, which includes engineering costs and contingency. The cost is based on minimal fiber infrastructure construction costs, and hub communication equipment required at the Tri-Valley Smart Corridor at the Pleasanton TMC.

5.1.3 Segment C

Segment C connects the BART fiber from the Walnut Creek Station access point to the future Caltrans Benicia Bridge hub. This segment consists of installing fiber in existing Caltrans conduit. The condition of this conduit needs to be verified during the design. The approximate distance for Segment C is 9.5 miles.

Along with I-680 hub connectivity to the Regional TMC, installing fiber along I-680 in this phase enables the opportunity to put approximately 18 existing CCTV cameras, four existing CMS, and 26 detector stations on the fiber as well.

The estimated cost for Segment C is $653,000, which includes engineering costs and contingency. The cost is based on fiber installation costs and communication equipment required for the CCTV, CMS, and detector stations.

5.1.4 Segment D

Segment D connects the Caltrans future hub at the Benicia Bridge to the Vallejo CHP. This segment is divided into two parts. There is existing Caltrans conduit and fiber from the Caltrans hub to the Benicia Bridge (approximately 0.5 miles). Approximately 5.7 miles of conduit and fiber are needed from the bridge to the Vallejo CHP on I-780 to complete the link. The approximate distance for Segment D is 6.2 miles.

Along with Vallejo CHP connectivity to the Regional TMC, installing fiber along I-780 in this phase enables the opportunity to put three existing CCTV cameras and one existing CMS on the fiber as well.

The estimated cost for Segment D is $1,561,000, which includes engineering costs and contingency. The cost is based on fiber infrastructure construction costs, hub communication equipment required at the Vallejo CHP, and communications equipment required for the CCTV and CMS.

5.1.5 Segment E

Segment E connects the BART fiber from the proposed new Civic Center Station access point to the San Francisco TMC (SFgo) using local agency conduit and fiber. The approximate distance for Segment E is 0.5 miles.

The estimated cost for Segment E is $117,000, which includes engineering costs and contingency. The cost is based on minimal fiber infrastructure construction costs, and hub communication equipment required at the San Francisco TMC (SFgo).

5.1.6 Phase Cost

The opinion of probable cost for the implementation of Phase 1 is:

Construction:	$3,079,000
Annual (Recurring)**:	$20,440

* Construction costs include fiber and conduit infrastructure, communication equipment, 20 % engineering, 15% contingency, and $500,000 for center-to-center software, equipment, and integration.

**Annual (Recurring) costs include fiber, hub and field communication equipment maintenance costs.

The breakdown of costs is detailed in Section 6.

5.2 Phase 2

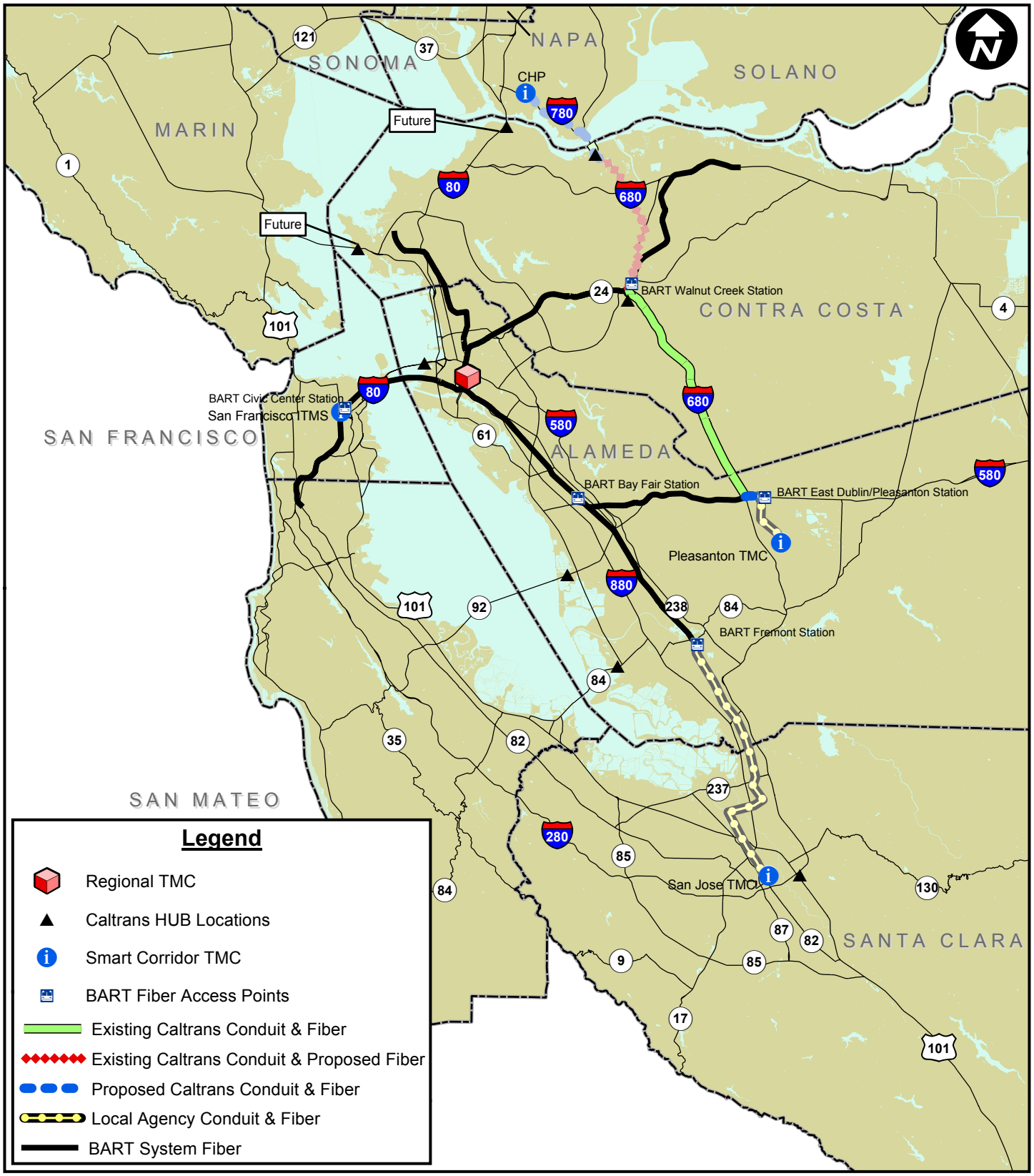
The primary objective of Phase 2 is to connect the existing fiber along I-680 between the Caltrans Walnut Creek hub and the East Dublin/Pleasanton BART station access point. The purpose of this segment serves three main purposes:

1. A fiber loop is formed between the Caltrans Walnut Creek hub, TriTri-Valley Smart Corridor TMC at Pleasanton and the Regional TMC. This loop offers path redundancy such that the communication backbone will be able to maintain full operation despite a fiber break anywhere on this loop (true ring).
2. Utilizing the fiber along the freeway in this phase enables the opportunity to connect approximately 26 existing CCTV cameras, one existing CMS and 58 existing detector stations, and 4 ramp meters to the fiber as well. Twenty-one of these cameras are already connected to the fiber.
3. The true ring requires only two fibers (SONET) or a single fiber (Gigabit Ethernet); thereby freeing up two or three previously used BART fibers.

The segment identified for Phase 2 is shown in **Figure 2**. The total distance covered in Phase 2 is approximately 20.1 miles through Contra Costa and Alameda counties.

5.2.1 Segment F

Segment F connects the Caltrans Walnut Creek hub to the West Dublin/Pleasanton Station access point through the existing Caltrans owned conduit and fiber along I-680. There is approximately 1.3 miles of proposed Caltrans conduit and fiber from the existing Caltrans fiber to the East Dublin/Pleasanton Station access point. The approximate distance for Segment F is 20.1 miles.



Communications Master Plan
Phase 2
Figure 2

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June 2002

5.2.2 Phase Cost

The opinion of probable cost for the implementation of Phase 2 is:

Construction*: $746,000
Annual (Recurring)**: $13,500

* Construction costs include fiber and conduit infrastructure, communication equipment, 20 % engineering and 15% contingency.

**Annual (Recurring) costs include fiber and communication equipment maintenance costs.

The breakdown of costs is detailed in Section 6.

5.3 Phase 3

The primary objective of Phase 3 is to connect other Caltrans hubs to the backbone. The Caltrans hubs that will gain connectivity to the Regional TMC via this phase are:

- Caltrans San Mateo Bridge hub;
- Caltrans Dumbarton Bridge hub;
- Caltrans Bay Bridge hub; and
- Caltrans San Jose, Knox Avenue hub.

The San Mateo, Dumbarton, and Bay Bridge hubs function as bridge CCTV security camera multiplexing hubs.

The segments identified for Phase 3 are shown in **Figure 3**. The total distance covered in Phase 3 is approximately 34.3 miles through Alameda and Santa Clara Counties.

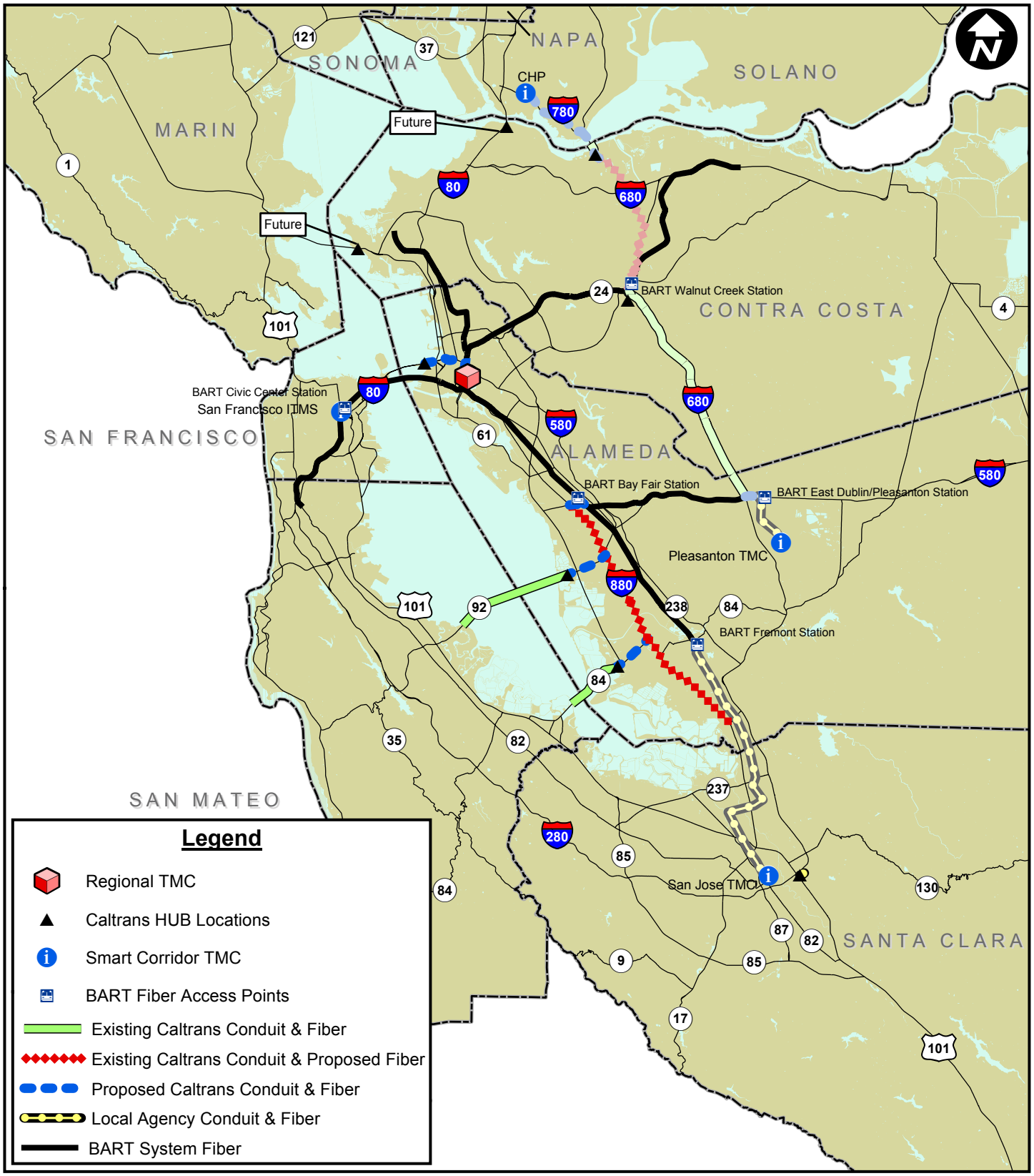
5.3.1 Segment G

Segment G connects the conduit on I-880 from the BART fiber at the Bay Fair Station access point to SR 84. This segment is divided into three parts.

1. Install conduit and fiber along I-238 from the Bay Fair Station access point (in I-238 right-of-way) to the existing Caltrans conduit along I-880 (approximately 2.0 miles).
2. Install fiber in existing Caltrans conduit along I-880 from the Davis Street interchange to a point just north of Mission Boulevard (approximately 18.5 miles). The condition of this conduit and usability of the pullboxes needs to be verified during the design.

Installing fiber along I-880 in this segment enables the opportunity to add approximately 21 existing CCTV cameras, three existing CMS and 29 existing detector stations on the fiber as well.

The estimated cost for Segment G is $945,000, which includes engineering costs and contingency. The cost is based on fiber infrastructure construction costs, and communication equipment required for the CCTV, CMS, and detector stations.



Communications Master Plan
Phase 3
Figure 3

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June 2002

5.3.2 Segment H

This segment will connect the Caltrans hub at the San Mateo Bridge to the Regional TMC. Segment H connects SR 92 from the Caltrans San Mateo hub to I-880. This segment calls for approximately 2.9 miles of new Caltrans conduit and fiber along SR 92. This will connect the existing 7.9 miles of Caltrans conduit and fiber along SR 92 to the backbone. The approximate distance for Segment H is 10.8 miles.

Installing fiber along I-880 and SR 92 in this segment enables the opportunity to add 11 existing CCTV cameras, four existing CMS, and the San Mateo Bridge security cameras on the fiber as well.

The estimated cost for Segment H is $872,000, which includes engineering costs and contingency. The cost is based on fiber infrastructure construction costs, and communication equipment required for the CCTV, CMS, and detector stations.

5.3.3 Segment I

This segment will connect the Caltrans Dumbarton Bridge hub to the Regional TMC. Segment I connects SR 84 from the Caltrans Dumbarton Bridge hub to I-880. This segment requires new Caltrans conduit and fiber along SR 84 that must be connected to the fiber along I-880. The approximate distance for Segment I is 3.8 miles.

Installing fiber and conduit along SR 84 in this segment enables the opportunity to add 11 existing CCTV cameras, two existing CMS, nine existing detector stations and the Dumbarton Bridge security cameras on the fiber as well.

The estimated cost for Segment I is $1,123,000, which includes engineering costs and contingency. The cost is based on minimal fiber infrastructure construction costs, and communication equipment required for the CCTV, CMS, and detector stations.

5.3.4 Segment J

This segment will connect the Caltrans hub in San Jose (Knox Ave.) to the Regional TMC via the Silicon Valley-ITS at the San Jose TMC. Segment J connects the Silicon Valley-ITS at the San Jose TMC to the Caltrans hub using proposed local agency conduit and fiber, and a short segment of new conduit and fiber along Story Road to the Caltrans hub. The approximate distance for Segment J is 3.2 miles.

The estimated cost for Segment J is $14,000, which includes engineering costs and contingency. The cost is based on minimal fiber infrastructure construction costs.

5.3.5 Segment K

Segment K connects the Bay Bridge Caltrans hub to the Regional TMC using proposed Caltrans conduit and fiber. The approximate distance for Segment K is 4.0 miles.

Utilizing the fiber along I-80 in this segment enables the opportunity to add 11 existing CCTV cameras, three existing CMS, 18 existing detector stations and the Bay Bridge security cameras on the fiber as well.

The estimated cost for Segment K is $1,241,000, which includes engineering costs and contingency. The cost is based on fiber infrastructure construction costs, and communication equipment required for the CCTV, CMS, and detector stations.

5.3.6 General

During the design, it is recommended that consideration be given to connecting the Knox Avenue Bart Station to the I-880 fiber optic system to provide another ring of redundancy for the TOS on I-880.

5.3.7 Phase Cost

The opinion of probable cost for the implementation of Phase 3 is:

Construction*: $4,100,000
Annual (Recurring)**: $21,150

* Construction costs include fiber and conduit infrastructure, communication equipment, 20 % engineering and 15% contingency.

**Annual (Recurring) costs include fiber and communication equipment maintenance costs.

The breakdown of costs is detailed in Section 6.

5.4 Phase 4

The primary objectives of Phase 4 are twofold, 1) to convert the US 101 communications from leased service to agency-owned fiber, and 2) supply fiber path redundancy for the following TMCs and hubs:

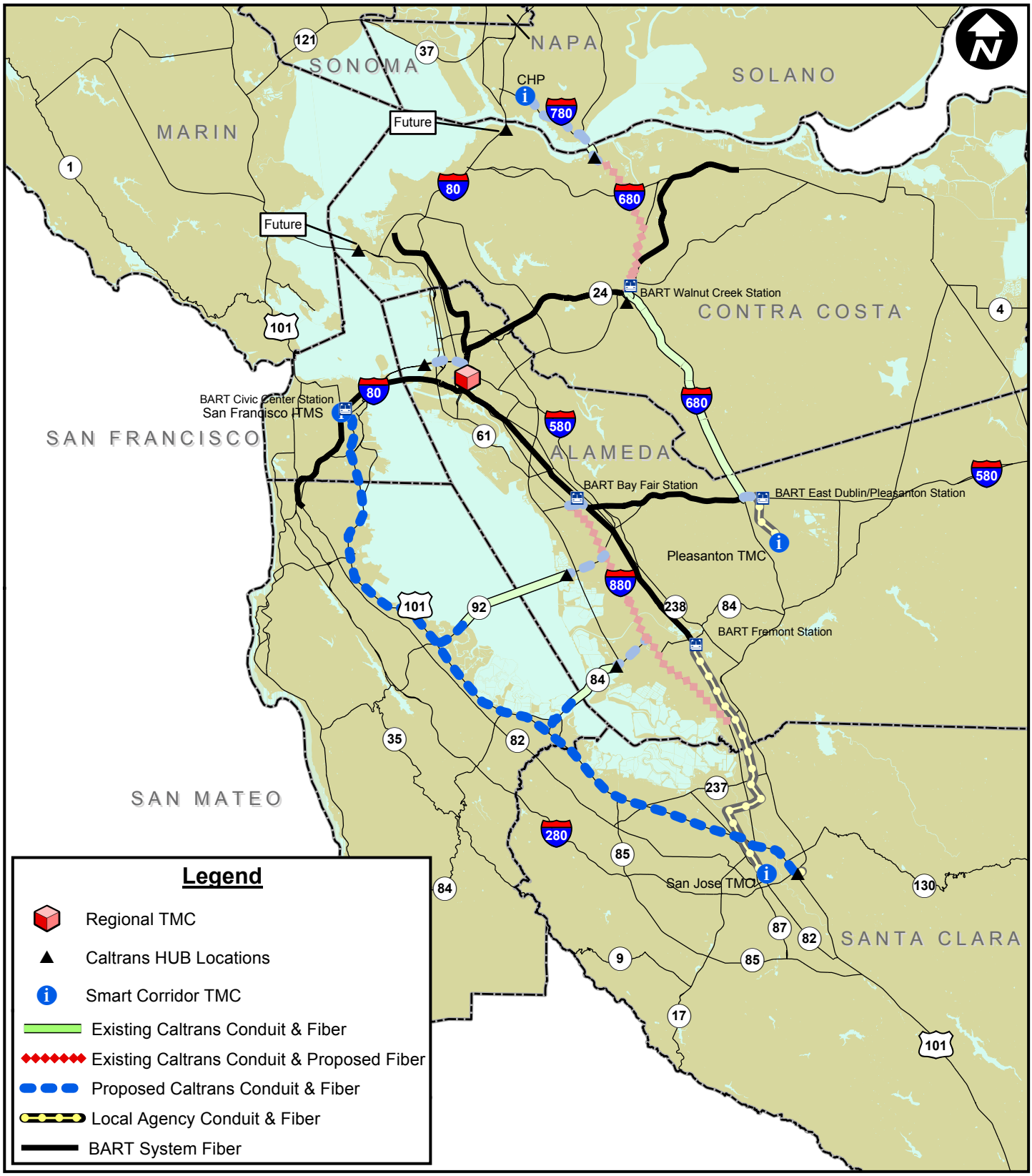
- Silicon Valley-ITS at the San Jose TMC;
- Caltrans San Jose hub;
- Caltrans Dumbarton Bridge hub;
- Caltrans San Mateo Bridge hub; and
- San Francisco TMC (SFgo).

Phase 4 is shown in **Figure 4**. Phase 4 covers approximately 49.5 miles going through San Francisco, San Mateo, and Santa Clara Counties. Due to the distance covered by this fiber run, and the multitude of field devices that would be brought onto the fiber, a hub is recommended on this fiber run on US 101 near the San Mateo Bridge. Phase 4 is split into two sub-phases (4A and 4B) to provide projects of reasonable size.

5.4.1 Segment L (Phase 4A)

Segment L (Phase 4A) connects the San Jose Caltrans hub to a new San Mateo Caltrans hub using proposed Caltrans conduit and fiber. This segment will run along US 101. The approximate distance for Phase 4A is 32.5 miles.

Installing fiber along US 101 in this phase enables the opportunity to put approximately 43 CCTV cameras, 10 CMS and 60 detector stations on the fiber as well.



Communications Master Plan
Phase 4
Figure 4

Kimley-Horn and Associates, Inc.

June 2002

5.4.2 Phase 4A Cost

The opinion of probable cost for the implementation of Phase 4A is:

Construction*: $8,970,000
Annual (Recurring)**: $21,720

* Construction costs include fiber and conduit infrastructure, hub communication equipment as well as communication equipment for CCTV, CMS, and detector stations, 20% engineering and 15% contingency.

**Annual (Recurring) costs include fiber and communication equipment maintenance costs.

The breakdown of costs is detailed in Section 6.

5.4.3 Segment M (Phase 4B)

Segment M (Phase 4B) connects the BART fiber from the proposed Civic Center Station access point to the new San Mateo Caltrans hub using proposed Caltrans conduit and fiber. This segment will also run along US 101. The approximate distance for Phase 4B is 22.7 miles.

Installing fiber along US 101 in this phase enables the opportunity to put approximately 24 CCTV cameras, 6 CMS, and 87 detector stations on the fiber as well.

5.4.4 Phase 4B Cost

The opinion of probable cost for the implementation of Phase 4B is:

Construction*: $6,439,000
Annual (Recurring)**: $14,680

* Construction costs include fiber and conduit infrastructure, as well as communication equipment for CCTV, CMS, and detector stations, 20% engineering and 15% contingency.

**Annual (Recurring) costs include fiber and communication equipment maintenance costs.

The breakdown of costs is detailed in Section 6.

5.5 Future Phases

Field elements not moved to the fiber backbone will remain on leased lines. These devices can be added to the fiber infrastructure in accordance with the Caltrans TOS Implementation Plan currently being developed.

6. COST BREAKDOWN BY PHASE

Table 3 identifies the Phases and the breakdown of each phase by the following:

- Segments, Routes;
- Counties;
- Distances; and
- Costs.

Note that the segments identified are used as reference tools.

Table 3 – Freeway Concept of Operations Build-out by Phase

Note that the construction estimate totals are rounded to the nearest thousand dollars.

PHASE 1										
Segment	Route	County	Fwy Coverage (mi.)[1]			COSTS				Notes
			Conduit & Fiber	Fiber	Total	Construction[2]	Comm. Equip[3]	Annual Maintenance (Fiber)[5]	Annual Maintenance (Comm)[6]	
A	Rte-238	Alameda	-	-	-	$10,000[4]	-	$0[7]	-	BART (Fremont) to Silicon Valley-ITS at the San Jose TMC
		Santa Clara	-	-		$10,000[4]	$75,000	$0[7]	$2,500	
B	I-580	Alameda	-	-	-	$10,000[4]	$75,000	$0[7]	$2,500	BART (E. Dublin/Pleasanton) to Tri-Valley Smart Corridor at the Pleasanton TMC
C	I-680	Contra Costa	-	9.5	9.5	$334,000	$139,000	$4,750	$2,280	BART (Walnut Creek) to Caltrans Benicia Bridge hub on I-680
D	I-680/780	Contra Costa	-	0.5	6.2	$1,038,880	-	$250		Caltrans Benicia Bridge hub on I-680 to Vallejo CHP
		Solano	5.7	-			$92,500	$2,840	$2,820	
E	I-80	San Francisco	-		-	$10,000[4]	$75,000	$0[7]	$2,500	BART (Civic Center) to San Francisco TMC (SFgo)
Totals			5.7	10	15.7	$1,869,000		$7,840	$12,600	
Engineering (20% of Const. & equip. costs)						$374,000				
Subtotals						$2,243,000				
Contingency (15%)						$336,000				
Center to center software and equipment						$500,000				
TOTAL COST						$3,079,000		$7,840	$12,600	

Table 3 – Freeway Concept of Operations Build-out by Phase (cont'd)

PHASE 2										
Segment	Route	County	Fwy Coverage (mi.)[1]			COSTS				Notes
			Conduit & Fiber	Fiber	Total	Construction[2]	Comm. Equip[3]	Annual Maintenance (Fiber)[5]	Annual Maintenance (Comm)[6]	
F	I-680	Contra Costa	0.5	-	1.8	$89,200	$205,000	$8,450[8]	$3,450	BART (Walnut Creek) to BART (E. Dublin/Pleasanton) 20.1 mi. total.
		Alameda	1.3	-		$231,920	$14,500	$1,600[8]		
Totals			1.8	-	1.8	$541,000		$10,050[8]	$3,450	
Engineering (20% of Const. & equip. costs)						$108,000				
Subtotals						$649,000				
Contingency (15%)						$97,000				
TOTAL COST						$746,000		$10,050	$3,450	

PHASE 3										
Segment	Route	County	Fwy Coverage (mi.)[1]			COSTS				Notes
			Conduit & Fiber	Fiber	Total	Construction[2]	Comm. Equip[3]	Annual Maintenance (Fiber)[5]	Annual Maintenance (Comm)[6]	
G	I-238	Alameda	2.0	-	2.0	$529,000	$156,000	$9,250	$2,360	BART (Bay Fair) to I-880 via I-238 to SR 84 on I-880
	I-880		16.5	-	16.5					
H	SR 92	Alameda	2.9	-	2.9	$565,360	$66,500	$5,400[9]	$1,190	Caltrans hub (SR 92) to fiber along I-880, 10.8 mi. total.
I	SR 84	Alameda	-	-	-	$743,920[4]	$73,500	$1,900[10]	$1,320	Caltrans hub (SR 84) to fiber along I-880, 3.8 mi. total
J	US 101	Santa Clara	0.5	-	-	$89,200[4]	-	$0[7]	-	Silicon Valley-ITS at the San Jose TMC to Caltrans hub (San Jose), 3.2 mi. total
K	I-80	Alameda	4.0	-	4.0	$809,600	$89,500	$2,000	$1,340	Regional TMC to Caltrans Bay Bridge hub (I-80)
Totals			25.9	7.8	19.4	$3,123,000		$18,550	$6,480	
Engineering (20% of Const. & equip. costs)						$625,000				
Subtotals						$3,748,000				
Contingency (15%)						$562,000				
TOTAL COST						$4,310,000		$18,550	$6,480	

PHASE 4A										
Segment	Route	County	Fwy Coverage (mi.)[1]			COSTS				Notes
			Conduit & Fiber	Fiber	Total	Construction[2]	Comm. Equip[3]	Annual Maintenance (Fiber)[5]	Annual Maintenance (Comm)[6]	
L	US 101	San Mateo	13.9	-	13.9	$2,628,410	$320,000[11]	$6,950	$3,215	New Caltrans hub at San Mateo Bridge
		Santa Clara	17.8	-	17.8	$3,365,590	$185,300	$8,900	$4,115	
Totals			31.7	-	31.7	$6,500,000		$15,850	$7,330	
Engineering (20% of Const. & equip. costs)						$1,300,000				
Subtotals						$7,800,000				
Contingency (15%)						$1,170,000				
TOTAL COST						$8,970,000		$15,850	$5,870	

Table 3 – Freeway Concept of Operations Build-out by Phase (cont'd)

PHASE 4B										
Segment	Route	County	Fwy Coverage (mi.)[1]			COSTS				Notes
			Conduit & Fiber	Fiber	Total	Construction[2]	Comm. Equip[3]	Annual Maintenance (Fiber)[5]	Annual Maintenance (Comm)[6]	
M	US 101	San Francisco	6.1	-	6.1	$1,182,560	$71,345	$3,050	$900	BART (Civic Center) to Caltrans hub (San Jose)
		San Mateo	16.6	-	16.6	$3,218,120	$194,155	$8,300	$2,430	
Totals			22.7	-	22.7	$4,666,000		$11,350	$3,330	
Engineering (20% of Const. & equip. costs)						$933,000				
Subtotals						$5,599,000				
Contingency (15%)						$840,000				
TOTAL COST						$6,439,000		$11,350	$3,330	

(1) This mileage depicted in this column pertains to newly installed infrastructure only, not necessarily the total segment length.
(2) Construction costs include:
- $178,400/mile for conduit and fiber installation
- $20,000/mile for fiber only installation
- $3,000 per CCTV, CMS, or detector station installation.

(3) Communication equipment costs include:
- $75,000 for WAN equipment
- $5,000 for VOTR pair and codec per CCTV
- $2,500 per OTR per CMS
- $1,500 per OTR per detector station.

(4) This cost assumes that the fiber is readily accessible in existing pull boxes.
(5) Fiber Maintenance costs are assumed to be $500 per mile.
(6) Communication Maintenance costs include:
- $2,500 for WAN equipment
- $50/codec
- $10/VOTR pair (CCTV)
- $10/OTR (CMS)
- $10/OTR (Det).

(7) Annual maintenance to be handled by the local agency.
(8) This cost is for the total fiber along the route (20.1 miles), not just the installed fiber (1.8 miles).
(9) This cost is for the total fiber along the route (10.8 miles), not just the installed fiber (2.9 miles).
(10) This cost is for the total fiber along the route (3.8 miles), all fiber is existing, no fiber to be installed.
(11) This includes $175,000 for WAN equipment and hub building.

7. IMPLEMENTATION PLAN

The Deployment Plan presented in a previous sections described the recommended means of building a communications backbone to serve the freeway operations needs for the Bay Area. Because of the shear size, complexity, and cost of implementing a regional communication system, the communications system needs to be developed and deployed in stages. In this section, the staged Implementation Plan is presented.

7.1 Phase 1

The implementation of Phase 1 will consist of the following primary activities:

- Connect the BART fiber at the Fremont BART Station access point to Silicon Valley-ITS at the San Jose TMC using the programmed Silicon Valley-ITS fiber optic cable;
- Install communications equipment at Silicon Valley-ITS at the San Jose TMC;
- Install communications equipment at Regional TMC;
- Activate BART fibers from Fremont BART Station access point to Regional TMC;
- Connect the BART fiber from the East Dublin/Pleasanton BART Station access point to the Tri-Valley Smart Corridor at the Pleasanton TMC using the programmed Tri-Valley Smart Corridor fiber optic cable;
- Install communications equipment at Tri-Valley Smart Corridor at the Pleasanton TMC;
- Install fiber optic cable in existing Caltrans conduit from Caltrans Walnut Creek hub to Caltrans Benicia Bridge hub;
- Install new conduit and fiber along I-680 from Caltrans Benicia Bridge hub to I-780 and along I-780 from I-680 to the CHP Division headquarters in Vallejo;
- Install communications equipment at CHP Division headquarters in Vallejo;
- Install communications equipment in TOS equipment cabinets along I-680 from Caltrans Walnut Creek hub to Caltrans Benicia Bridge hub, and bring existing TOS field equipment on-line;
- Connect the BART fiber from a new BART fiber access point near the Civic Center BART Station to the San Francisco TMC (SFgo) using proposed ITMS fiber optic cable;
- Execute Memorandums of Understanding between Caltrans, CHP, MTC, Silicon Valley-ITS agencies, East Bay Smart Corridor agencies, San Francisco, and Tri-Valley Smart Corridor agencies; and
- Complete systems integration work to bring center-to-center communications into operation and begin real-time exchange of video images and other data.

7.2 Phase 2

The implementation of Phase 2 will consist of the following primary activities:

- Install new conduit and fiber optic cable from the Caltrans Walnut Creek hub to the conduit and fiber optic cable on I-680;
- Install new conduit and fiber optic cable from the East Dublin/Pleasanton BART Station access point along I-580 to join Caltrans conduit and fiber on I-680;

- Install communications equipment in TOS equipment cabinets along I-680 from I-580 to SR 24; and
- Activate Caltrans fiber optic cable along I-680 from the East Dublin/Pleasanton BART Station access point to the Caltrans Walnut Creek hub and bring the existing TOS field equipment on-line.

7.3 Phase 3

The implementation of Phase 3 will consist of the following primary activities:

- Install conduit and fiber optic cable along I-238 from the Bay Fair BART Station access point to the existing Caltrans conduit along I-880;
- Install fiber in existing Caltrans conduit along I-880 from the Davis Street interchange to the Alvarado-Niles Road interchange;
- Install conduit and fiber optic cable along I-880 from the Alvarado-Niles interchange to SR 84 to connect the existing Caltrans conduit to SR 84 conduit;
- Install communications equipment in TOS equipment cabinets along I-880 and I-238 from the Bay Fair BART Station access point to SR 84;
- Install new conduit and fiber optic cable along SR 92 from the Caltrans San Mateo Bridge hub to I-880;
- Connect the fiber optic cable in existing Caltrans conduit along SR 84 from the Caltrans Dumbarton Bridge hub to join the I-880 fiber optic cable;
- Install communications equipment in TOS equipment cabinets along SR 84 from the Caltrans Dumbarton hub to I-880;
- Install communications equipment at Caltrans San Mateo Bridge hub;
- Install communications equipment at Caltrans Dumbarton Bridge hub;
- Activate fiber optic cable and field equipment along SR 84, SR 92, I-880, and I-238;
- Install communications equipment at Regional TMC to communicate with the Phase 3 field equipment;
- Activate Silicon Valley-ITS fiber optic cable from the Silicon Valley-ITS at the San Jose TMC to the Caltrans San Jose hub; and
- Install conduit and fiber optic cable along I-80 and I-580 from the Caltrans Bay Bridge hub to the Regional TMC, and activate fiber optic cable.

7.4 Phase 4

Phase 4 is split into two projects to spread the budget over multiple years.

Phase 4A – The primary objective of Phase 4A is to build the portion of the Phase 4 backbone from a new Caltrans San Mateo Bridge hub to the Silicon Valley-ITS at the San Jose TMC and create another redundant ring, in the process.

The implementation of Phase 4A will consist of the following primary activities:

- Install new Caltrans hub at the San Mateo Bridge;
- Install new conduit and fiber optic cable along US 101 from the new Caltrans San Mateo Bridge hub to the Caltrans San Jose hub; and
- Install communications equipment in the TOS equipment cabinets along US 101 from the new Caltrans San Mateo Bridge hub to I-280/I-680 in San Jose.

Phase 4B – The primary objective of Phase 4B is to build a portion of the Phase 4 backbone from San Francisco to the San Mateo Bridge and create a redundant ring, in the process.

The implementation of Phase 4B will consist of the following primary activities:

- Install new conduit and fiber optic cable along US 101 and I-280 from the new access point near the Civic Center BART Station to the new Caltrans hub at the San Mateo Bridge;
- Install communications equipment in the TOS equipment cabinets along US 101 from the new access point near the Civic Center BART Station to the new Caltrans San Mateo hub; and
- Install communications equipment at Regional TMC to communicate with the Phase 4B field equipment.

8. IMPLEMENTATION SCHEDULE

An implementation schedule was prepared to spread the design and construction activities over multiple years. This schedule is depicted in **Figure 5**. This approach will enable the projects to be budgeted in increments and thus make the funding more manageable. If funding becomes available more quickly than laid out in the implementation schedule, the projects can be started earlier than depicted. If larger than planned amounts are budgeted for any given year, the projects may be combined resulting in an accelerated completion schedule.

This implementation schedule is interrelated with the schedule for the smart corridor TMCs and TravInfo® coming on line. The current operational dates for the smart corridor TMCs and TravInfo® are identified as follows:

- Silicon Valley-ITS at the San Jose TMC – September 2003;
- Tri-Valley Smart Corridor at the Pleasanton TMC – September 2003;
- San Francisco TMC (SFgo) – September 2003; and
- TravInfo® – August 2002.

The schedule for Phase 1 of the communications backbone is to complete the center to center connections to the Silicon Valley-ITS at the San Jose TMC, Tri-Valley Smart Corridor at the Pleasanton TMC, and San Francisco TMC (SFgo) (Segments A, B and E) by early 2004 and the connection to Vallejo CHP (Segments C and D, which involve new construction in freeway rights-of-way) by September 2004. The above operational dates show that there will be smart corridor TMCs to connect at that time the first phase is implemented. .

The schedule calls for the necessary Memorandums of Understanding to be prepared and approved by the three regional agencies and the various local agencies in 2002. These MOUs must address the details of the funding, the lead agency for the design and the construction, the operations responsibilities and the agencies responsible for the maintenance of the system. The design for Phase 1 could begin as soon as funds have been secured and the lead agency is designated

The design periods for each of the phases require six to twelve months depending on the complexity and the amount of design work that is required. The construction periods are shown as nine months to fifteen months in duration. These construction periods include a three-month period for advertising and bidding before construction begins. This schedule will enable all four Phases to be operational by the end of 2010. In addition to the phases of communications backbone implementation described in this report, there are opportunities to incrementally deploy other components of the communication system. As Caltrans undertakes construction projects along the routes where communications cable will be needed, it is recommended that conduit and pull boxes be included in those projects. This will build some of the basic infrastructure while the roadway is under construction for other purposes, and then this infrastructure will be available for fiber optic cable installation at a future date. The incremental cost to add the conduit and pull boxes will be very small percentage of the total project cost. The percentage could be as small as one percent of the total construction cost. It is recommended that Caltrans adopt a procedure where this approach is followed as part of the standard design process.

Bay Area
Freeway Concept of Operations
Communications Implementation Plan
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Figure 5 - Implementation Schedule

Projects	Budget	2002				2003				2004				2005				2006				2007				2008				2009				2010			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Phase 1 - MOUs																																					
Phase 1 - Design	$374,000																																				
Phase 1 - Construction (1)	$2,705,000																																				
Phase 2 - Design	$108,000																																				
Phase 2 - Construction	$638,000																																				
Phase 3 - Design	$625,000																																				
Phase 3 - Construction	$3,685,000																																				
Phase 4A - Design	$1,300,000																																				
Phase 4A - Construction	$7,670,000																																				
Phase 4B - Design	$933,000																																				
Phase 4B - Construction	$5,506,000																																				
TOTAL BUDGETS	**$23,544,000**																																				

(1) Budget includes $500,000 for center-to-center software and equipment.

9. FUNDING

The required funding for each of the next five years is summarized in **Table 4** that follows.

Table 4 – Summary of Required Funding

Year	Design	Construction	Total
2003	$482,000	N/A	$482,000
2004	N/A	$3,343,000 (1)	$3,343,000
2005	$625,000	N/A	$625,000
2006	N/A	$3,685,000	$3,685,000
2007	$2,233,000	N/A	$2,233,000
2008	N/A	$7,670,000	$7,670,000
2009	N/A	$5,506,000	$5,506,000
TOTAL	**$3,340,000**	**$20,204,000**	**$23,544,000**

(1) – Includes $500,000 for center-to-center software and equipment

This funding schedule assumes that funds are obtained from public sources. Accurately forecasting and securing stable funding for ITS has proved difficult in many regions. A recent survey of transportation agencies by the Institute of Transportation Engineers (ITE) revealed an average 20 percent shortfall in funding and resources for traffic control activities by those agencies. As activities are expanded, the need for deployment and operations funding becomes even more critical. Long-term funding of operations and maintenance activities is of particular concern.

Focusing increased efforts on planning and budgeting Operations and Maintenance costs to accurately predict these costs over the life cycle of proposed deployments is perhaps the best strategy related to the funding of a communications system. When the full life-cycle costs of ITS are properly planned and accurately anticipated, the task of finding available funding sources for financing the implementation and operation of the deployment is made infinitely easier.

The requirements for many federal funding opportunities require that ITS be planned consistent with the guidelines provided in the National ITS Architecture. The Transportation Equity Act for the 21st Century (TEA-21) legislation continues eligibility for funding of operating costs for traffic monitoring, management, and control. While continuing to permit annually apportioned Federal-aid funds to be eligible for traffic systems operations and management activities, TEA-21 does not provide separate funding exclusively for system management and operations. Available general funding programs include:

- **National Highway System (NHS) –** Provides for capital and operating costs for traffic monitoring, management, and control facilities and programs. Funds provided on an 80/20 percent federal/local match basis with no time limit for operations.
- **Surface Transportation Program (STP) –** Provides for capital and operating costs for traffic monitoring, management, and control facilities and programs. Funds provided on an 88.5/11.5 percent federal/local match basis within the initial project scope.
- **Congestion Mitigation and Air Quality Improvement Program (CMAQ)** – Provides funds for the establishment or operation of traffic monitoring, management, and control facility or program in non-attainment areas. Explicitly includes, as an eligible condition for funding,

programs or projects that improve traffic flow. Funds provided for O&M on an 88.5/11.5 percent federal/local match basis for three years, or longer if the project demonstrates air quality benefits on a continuing basis.

TEA-21 also authorized additional Federal funding mechanisms which are available specifically to aid in the deployment and operation of ITS. These funds have been largely apportioned through congressional earmarks and include the following program:

ITS Integration – This component of the ITS Deployment Program provides funding for activities necessary to integrate ITS infrastructure components that are either deployed (existing) or will be deployed with other sources of funds. On behalf of MTC, CHP, San Francisco and San Jose, Caltrans submitted a $5 million application to FHWA for Fiscal Year 2003 Intelligent Transportation Systems Deployment Program. The focus of this program is to provide incentive monies for the deployment and/or integration of ITS to enhance the security of our surface transportation systems. The ITS Integration Program can fund up to 50 percent of an integration project's costs with a minimum of 20 percent of the local match to come from non-federally derived sources.

ITS projects will increasingly be called on to compete for the same construction and operating funding as traditional infrastructure projects. There may be opportunistic situations; however, to secure dedicated funding for specific ITS deployments if and when the funds become available. Periodic inquiries to regional FHWA representatives should be used to identify these potential opportunities.

On the state level, SHOPP funds and STIP funds are eligible for use to build the communications backbone, but again, the use of these funds is dependent on the prioritization given to these communications backbone projects.